Pratt & Whitney

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A three-dimensional, linearized, unsteady aerodynamic analysis has been developed for aeroacoustic design applications. This analysis, called LINFLUX is based on the Euler equations and has been applied to predict the aeroacoustic response of the 22" Advanced Ducted Propulsor (ADP) Fan Exit Guide Vane (FEGV) to rotor wake excitations. The blades of the FEGV are highly three-dimensional, with twist, bow and flare at the tips. In predicting the unsteady response of this blade row, measurements taken downstream of the ADP rotor at NASA Glenn Research Center, together with empirical correlations were used to determine the strength and circumferential variation of the viscous rotor wake excitation. Numerical runs were carried out for disturbances at the first two multiples of the blade passing frequency (BPF). Sample results for the 1- and 2-BPF excitation are presented in Figures 1(a) and 1(b), which illustrate contours of the unsteady pressure at 94%-span. In the former case, the acoustic field is damped (cut off) upstream and downstream of the blade row while in the latter, propagating acoustic responses occur at both inlet and exit. Further analysis shows that four such acoustic modes are present at the inlet and exit, indicating a rich spectrum. Based on the numerical solution for the unsteady flow in the blade row, the total downstream sound power level was determined to be 125.4 dB, which agrees well with the value measured experimentally at NASA Glenn. Although this agreement is somewhat fortuitous in view of the approximations that were made, it indicates that the modeling approach is viable as an analysis tool for future design systems. Furthermore, it may be profitably employed to provide an understanding of the unsteady flow physics associated with blade-row noise generation.

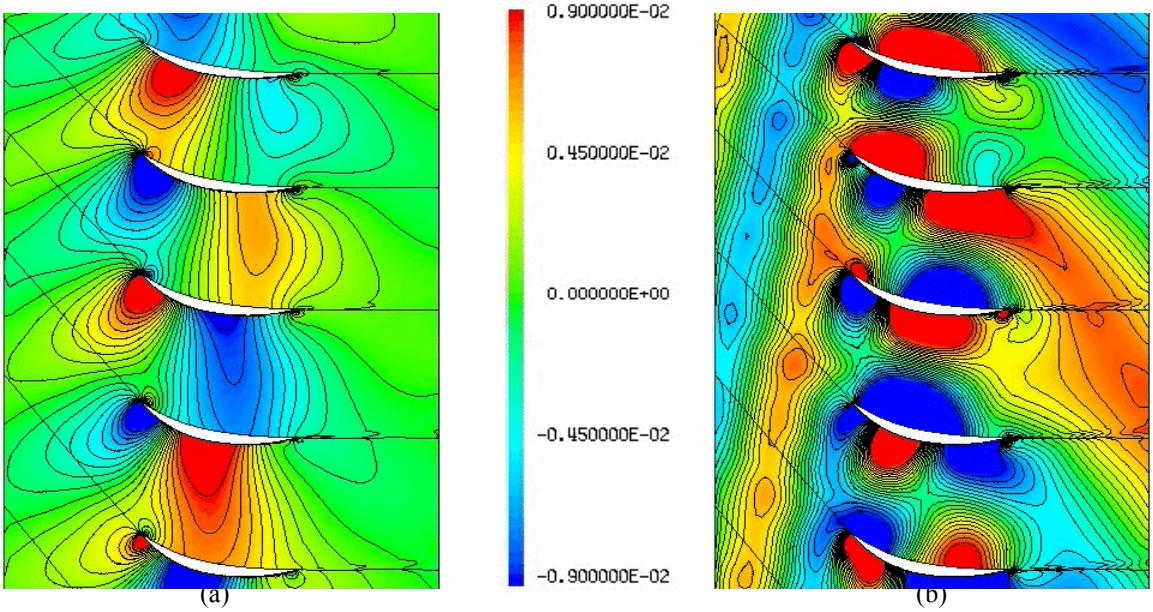

Figure 1. Unsteady pressure response of the ADP FEGV at 94%-span at (a) 1-BPF, and (b) 2-BPF. The excitation amplitudes were determined from NASA Glenn experimental data. It is evident that the response is cutoff in case (a), while propagating disturbances appear at inlet and exit in case (b).